# ARIANE AUXILIARY PAYLOAD APPLICATIONS TO EARTH AND LUNAR MISSIONS*

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## ABSTRACT

A viable method has been developed in the past two years which can deliver small spacecraft, carried on Ariane GEO missions, to specific planets and other bodies in the solar system. This procedure, called Moon and Earth Gravity Assist (MEGA, see references) allows compatibility with an any-time Ariane launch over a 3-month or longer period. This paper discusses a similar but independent problem, and that is the methods which may be used to deliver auxiliary payloads from GTO (geosynchronous transfer orbit) to low or high Earth orbits (LEO and HEO), or to the Moon or libration points.

Whereas the MEGA method was needed to orient the trajectory to allow the spacecraft to execute an escape burn on a pre-specified date and into a required escape direction, no single method will apply to the possible variety of Earth and lunar missions. For this reason, several other technologies, such as solar electric propulsion and aerobraking will be called upon. This can be illustrated with a simple example; and that is going from the GTO equatorial orbit to a LEO sun synchronous orbit. Here, a direct transfer would require nearly 4000 m/s, which is much more than using MEGA to go to Mars or Venus. For an efficient chemical propulsion system, this implies that 70% of the initial mass would have to be propellant. Nevertheless, there are indirect transfer methods and alternate technologies which can lower or replace these requirements and these will be discussed here.

A primary emphasis in this paper will be to develop the required strategies for each type of mission which would be used for an any-time Ariane launch over a 3-month period. That is, how to handle transfers for situations when the orientation of the actual GTO flown is not favorable for the specific mission goal. This could be the case since the auxiliary payload team will have no say on the day or hour of the day when the Ariane will be launched. For example, the GTO major axis is normally close

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to the ecliptic (or lunar orbit) plane for spring and fall launches, but can be 20 to 30 degrees inclined for summer and winter launches. This higher inclination makes it more difficult to get to the Moon, or to use lunar flybys to shape trajectories on return to Earth. The propulsion requirements will be generated for these cases.

This variation in the GTO orientation can be addressed in various ways. One would be to wait in GTO and let Earth gravity harmonics cause nodal regression and perigee progression for the time required to place the GTO orientation more favorably for lunar transfer. Another would be to perform the necessary plane change at GTO perigee, or at some point along the way to the Moon (similar to the planetary "broken plane") to obtain a lower total velocity requirement. A third would be to use the MEGA process of going beyond the Moon, where a low velocity is needed to do the plane change required to get to the Moon. These methods will be compared for various types of missions.

Finally, lunar capture using the weak stability boundary has been a fascinating technique since it was used for the Hiten spacecraft recovery in 1990 by Belbruno and Miller. If such a mission were flown piggyback on the Ariane, it would be necessary to ensure that one or a variety of methods could be used to effect the lunar capture. A preliminary look at this problem will be included in this paper.

## REFERENCES


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